EA 05-0F6500
05-SCR-1-PM 14.96 to 15.94
KP 24.08 to 25.65

Highway 1 Soquel to Morrissey Auxiliary Lanes Project
Santa Cruz County, California

Drainage Impact Summary Report

Prepared for:

SCCRTC

NOLTE
BEYOND ENGINEERING

Prepared by:

WRECO

September 2008

EA 05-0F6500
05-SCR-1-PM 14.96 to 15.94
KP 24.08 to 25.65

Highway 1 Soquel to Morrissey Auxiliary Lanes Project
Santa Cruz County, California

Drainage Impact Summary Report

Submitted to:
Santa Cruz County Regional Transportation Commission

This report has been prepared by or under the supervision of the following Registered Engineer. The Registered Civil Engineer attests to the technical information contained herein and has judged the qualifications of any technical specialists providing engineering data upon which recommendations, conclusions, and decisions are based.

Han-Bin Liang, Ph.D., P.E.
Registered Civil Engineer

9/16/2008
Date

September 2008

Table of Contents

Figures

Tables

Photos

Appendices

Executive Summary

The purpose of the Highway 1 Soquel to Morrissey Auxiliary Lanes Project (hereto known as the "Project") is to reduce highway congestion caused by traffic weaving and merging operations on Highway 1 (State Route 1) between Soquel Drive and Morrissey Boulevard. The Project consists of adding 1 mile (1.6 km) of auxiliary lanes along Highway 1 in Santa Cruz County, California. The alternatives under consideration are a No-Build Alternative and Build Alternative.

This report identifies existing hydrologic and hydraulic conditions, highway drainage design elements, and hydrologic and hydraulic design standards for the Project.

The Project design goal will be to maintain pre-construction storm water discharge flows. The proposed drainage systems within the Project limits will be designed to intercept storm water runoff from the roadway and the areas adjacent to the Caltrans right-of-way. Due to the increase in roadway area as a result of this Project, new longitudinal drainage systems may be proposed to accommodate the increase in flow. Detailed hydrologic and hydraulic calculations will be performed as the Project progresses into its design phase.

Preliminary calculations of the cross culverts were performed for the major creek crossings within the Project limits. These calculations showed that the 4 feet by 4 feet (1200 mm by 1200 mm) culvert of the tributary to Arana Gulch at Station 177+92 is undersized and drainage design improvements will need to be proposed to accommodate the incoming flow. With the addition of retaining walls, new longitudinal systems as well as impacts to existing drainage systems, will be considered. Flow diversion will be kept to the minimum extent practicable.

Local agency requirements as well as regulatory requirements must be met for any drainage improvements proposed affecting local drainage systems and work in jurisdictional areas. To meet these regulatory requirements, the Project's design goal will be to meter or detain storm water flows to pre-construction rates prior to discharge to a receiving water body or Municipal Separate Storm Sewer System. In addition, this Project will not significantly affect the existing drainage patterns and will try to address the increased roadway runoff from the proposed widening by implementing outlet protection, velocity dissipation devices, and possible peak flow attenuation basins, if required. The additional flows are not significant in comparison to the overall watershed of the receiving water bodies of the Project. In addition, the Project will consider Best Management Practices, including water quality measures, to address potential temporary and permanent water quality impacts from the Project.

Acronyms

AC	Asphalt concrete
ACOE	Army Corps of Engineers
APC	Alternative pipe culvert
BMP	Best Management Practice
Caltrans	California Department of Transportation
CDFG	California Department of Fish and Game
ESA	Environmentally Sensitive Area
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIS	Flood Insurance Study
HDM	Highway Design Manual
HDS	Highway Design Series
HEC	Hydraulic Engineering Circular
IDF	Intensity Duration Frequency
NB	Northbound
NRCS	Natural Resources Conservation Service
OHWM	Ordinary high water mark
PS&E	Plans, Specifications, and Estimates
RCB	Reinforced concrete box
RSP	Rock Slope Protection
RWQCB	Regional Water Quality Control Board
SCAS	Spatial Climate Analysis Service
Sta.	Station
USDA	United States Department of Agriculture

1 PROJECT DESCRIPTION

The proposed project extends for a distance of 0.98 mile from the southbound Soquel Avenue off-ramp to the northbound Morrissey Boulevard on-ramp (post mile 14.96 to post mile 15.94) in the City of Santa Cruz, Santa Cruz County, California. Maps of the project vicinity and location are included below in Figures 1& 2.

1.1 Project Purpose

The purpose of the Soquel to Morrissey Auxiliary Lanes Project is to improve traffic conditions for lane-changing and merging movements on Highway 1 between Soquel Avenue and Morrissey Boulevard and improve pedestrian and bicycle access and safety.

1.2 Project Need

Identified needs include recurrent congestion from impeded lane-changing and merging movements, queuing traffic from the southbound bottleneck at the La Fonda Avenue overcrossing, and limited pedestrian and bicycle access crossing Highway 1 in the project area.

1.3 Alternatives

Two alternatives are under consideration: one Build Alternative and the No-Build Alternative.

1.3.1 Build Alternative

The Build Alternative would add one 12-foot-wide auxiliary lane from the Soquel Avenue on-ramp to the Morrissey Boulevard off-ramp in the northbound direction and extend a12-foot-wide lane from about 500 feet north of the La Fonda Avenue overcrossing to the Soquel Avenue off-ramp in the southbound direction, with 10-foot outside shoulders between the Soquel Avenue and Morrissey Boulevard interchanges. An auxiliary lane extends from the on-ramp of one interchange to the off-ramp at the next interchange and is designed to separate traffic movements entering and exiting the freeway from mainline traffic. It is not designed for use by through traffic. The project also would replace the La Fonda Avenue overcrossing.

A typical auxiliary lane would be constructed northbound from the Soquel Drive on-ramp to the Morrissey Boulevard northbound off-ramp (0.7 mile). On southbound Highway 1, the new outside lane being constructed with the State Route 1/ State Route 17 Merge Lanes Project would be extended from north of the La Fonda Avenue overcrossing to the Soquel Avenue exit ramp (0.3 mile). This lane would be "exit only" at Soquel Avenue, and the widening would eliminate the outside lane-drop north of La Fonda. No changes would be made to the Soquel Avenue or Morrissey Boulevard ramps. Retaining walls are proposed at several locations to reduce the amount of earthwork required, keep the improvements within the existing highway right-of-way and minimize impacts to

wetlands and other waters of the U.S. Soundwalls found to be feasible and reasonable based on current cost estimates also are recommended.

Additionally, the La Fonda Avenue overcrossing would be replaced and widened to accommodate the proposed auxiliary lanes. The new bridge would provide for two 12-foot-wide traffic lanes, as well as five-foot-wide bicycle lanes and six-foot-wide pedestrian sidewalks in both directions.

The project also would demolish the existing La Fonda Avenue overcrossing and existing roadway shoulder, and require earthwork and fill and temporary easements for construction of the overcrossing replacement and a temporary pedestrian/bicycle crossing. Disposal will be in accordance with all applicable regulations at locations to be identified at the final design phase. There is no permanent right-of-way impact anticipated for this alternative. Temporary easements of City of Santa Cruz property and two privately owned properties would be required.

Local street improvements, including new five-foot-wide sidewalks, curb, and gutter on the north side of Rooney Street and Morrissey Boulevard between Elk Street and San Juan Avenue, also would be constructed. This work would include four accessible driveway approaches and four pedestrian ramps in compliance with the Americans with Disabilities Act.

1.3.2 No-Build Alternative

The No-Build Alternative would not address the project purpose and need but offers a basis for comparison with the Build Alternative. It assumes no major construction on Highway 1 through the project limits other than planned and programmed improvements and continued routine maintenance. The only planned and programmed improvement contained in the 2005 Regional Transportation Plan is the State Route 1/ State Route 17 Merge Lanes Project, which is currently under construction with completion set for fall 2008; it is considered as part of existing conditions for the Soquel to Morrissey Auxiliary Lanes Project. The Highway 1 High Occupancy Vehicle Lane Widening Project is also planned, but is not included in the No-Build Alternative, as it is not yet programmed and will not be completed by the 2015 opening year for the Soquel to Morrissey Auxiliary Lanes Project.

1.4 Reference Documents

1.4.1 As-Built Record Documents

- Saunders, S. (Resident Engineer). As-Built Plans. (2001). Contract No. 04-135334. Date July 20. 2001. CU 04229. EA 135331. Sheet D-11.

1.4.2 Preliminary Layout Sheets

- L-1 Preliminary Plans – June 8, 2007
- L-2 Preliminary Plans – June 8, 2007

- L-3 Preliminary Plans – June 8, 2007

1.4.3 Geographical References

The following USGS Topographic Maps were utilized in preparing exhibits for this report.

- Santa Cruz, CA. Map Version: 1987. Map Current as of 1994.
- Soquel, CA. Map Version: 1997. Map Current as of 1994.

1.5 Soil Characteristics

The Web Soil Survey from the Natural Resources Conservation Service has information on Hydrologic Soil Groups which is based on estimates of runoff potential. The soil types for the segment of the Project area from Morrissey Boulevard to Soquel Avenue are predominately Elkhorn sandy loam, Nisene-Aptos complex, Pinto loam, Soquel loam, and Watsonville loam. (United States Department of Agriculture, Natural Resources Conservation Service, 2007). Hydrologic Soil Groups for the Project are documented in the *Water Quality Study Report* (WRECO, 2008).

A geotechnical study was conducted by Parikh Consultants, Inc. as part of the Project; only individual bridge locations were assessed. The Project limits, between Morrissey Boulevard and Soquel Avenue, are within those study limits, including at the Morrissey Boulevard Overcrossing and the La Fonda Avenue Overcrossing. The study indicates that liquefaction potential is low at these two locations but it should be further investigated in the design phase. Further verification and investigation is required at the Soquel Avenue/Soquel Drive Overcrossing. Project site subsoils generally consist of lowest emergent coastal terrace deposits at the Morrissey Boulevard Overcrossing and undifferentiated alluvial deposits and Purisima Formation at the La Fonda Avenue Overcrossing (Parikh, 2008).

1.6 Land Use

The land use in the vicinity is developed with some open lots and surrounding vegetation. The surrounding areas are mostly residential and commercial.

The estimated population for Santa Cruz County in 2006 was 254,538. There are four incorporated cities within Santa Cruz County. The Project is between two of these cities, the City of Santa Cruz, with a population of 54,593, and Capitola, with a population of 10,033.

Santa Cruz County has a land area of 445 square miles (1152.54 square kilometers). Land use consists mostly of residential and vacant land, with minor commercial and industrial developments.

1.7 Creeks, Streams, and River Crossings

Four waterways cross Highway 1 along the Project reach: Arana Gulch and three tributaries. These are the highway's direct receiving water bodies.

These four creek crossings were located from reviewing as-built record drawings, WRECO's site visits, and the *Wetland Assessment* by Morro Group (2008). The crossing culvert at Station 171+03 for Arana Gulch was identified as a concrete arch culvert from WRECO's observations and the size was identified as a 72 inch (1800 mm) concrete culvert in the *Wetland Assessment*. The 48 inch (1200 mm) concrete culvert for the tributary to Arana Gulch at Station 175+98 was not located during WRECO's field visit but was identified by Morro Group (2008). The 30 inch (750 mm) reinforced concrete pipe culvert for the tributary to Arana Gulch at Station 183+01 is outside of the area of improvement but within the Project limits. These creek crossings and their respective sizes are listed in Table 1, which also includes information on the creek crossing at Station 177+92, a 4 feet by 4 feet (1200 mm by 1200 mm) reinforced concrete box culvert.

Table 1. Creek Crossings

Waterway	Station	Culvert Size	
		Metric	English
Arana Gulch	171+03	1800 mm (height) concrete arch culvert	72" (height) concrete arch culvert
Tributary to Arana Gulch	175+98	1200 mm concrete culvert	48" concrete culvert
Tributary to Arana Gulch	177+92	1200 mm x 1200 mm reinforced concrete box culvert	4' x 4' reinforced concrete box culvert
Tributary to Arana Gulch	183+01	750 mm reinforced concrete pipe culvert	30" reinforced concrete pipe culvert

1.8 Existing Drainage and Drainage Design Issues

The existing drainage system for the Project limits is comprised mostly of cross culverts, asphalt concrete dikes with inlets to collect storm water at shoulders, overside drains, and roadside drainage ditches in the median.

Principal features of the Project that impact existing drainage features include the widening of the roadway and the new retaining walls proposed at the edge of shoulders. The undersized culverts will need to be replaced with larger sizes (or parallel systems) and additional inlets and new longitudinal systems may need to be specified to meet the current drainage design requirements (5 minute time of concentration). Existing drainage systems at the edge of shoulders may need to be relocated or new systems will need to be proposed to address the new retaining walls. There are no proposed drainage improvements outside of Caltrans' right-of-way. Upstream off-site drainage areas flowing through cross culverts will be maintained and downstream drainage systems will need to be evaluated for any impacts.

In general, the Project will not significantly affect the existing drainage patterns and will try to address the increased roadway runoff from the proposed widening by implementing outlet protection, velocity dissipation devices, and possible peak flow attenuation basins.

The additional flows are not significant in comparison to the overall watershed of the receiving water bodies of the Project.

1.9 Drainage Design Criteria

In the final design phase, the drainage design for the Project will be based on procedures presented in the updated fifth edition of the *Highway Design Manual* from Caltrans and those presented in the *Hydraulic Engineering Circular* Number 22 publication for highway pavement drainage from the United States Department of Transportation, Federal Highway Administration.

For cross culverts, drainage improvements will be evaluated and designed based on the criteria of passing the entire 10-year event within the cross culvert and the 100-year event without objectionable backwater. The final onsite hydrology calculations for this segment should utilize the Rational Method, Natural Resources Conservation Service TR-55 Method, or United States Geological Survey Regional Regression Equations to predict storm water runoff. For all culverts, two calculation methods should be used to predict storm water runoff.

Roadway drainage design discharges for the longitudinal systems will be based on the 25-year recurrence interval with water spread in the shoulder area permitted, as detailed in Section 830 of the *Highway Design Manual*, Table 831.3.

In addition, The *Highway Design Manual* recommends a time of concentration of 5 minutes for urban areas and 10 minutes for rural areas (*Highway Design Manual*, Section 832.3). A time of concentration of 5 minutes will be used for the calculations for this Project since the watersheds are mostly from urban paved surfaces.

The County of Santa Cruz's *Design Criteria w*as used to determine rainfall intensity and Intensity-Duration-Frequency curves (June 2006).

The Project is located in the City of Santa Cruz in the County of Santa Cruz. Any drainage improvements proposed for the local roads that are impacted by the Project, and any other off-site drainage systems impacted by the Project, will conform to these local agency requirements. At this point in the Project development, the detailed drainage design is not finalized. Additional discussion and calculations will be prepared in the final design phase.

1.10 Special Circumstances

Floodplains and environmentally sensitive areas exist within the Project limits. Impact to the environmentally sensitive areas shall be minimized to the extent practicable. Preliminary studies by the environmental team are currently ongoing and wetlands to be protected within the Project limits will be shown in the Project plans. Flows currently going into environmentally sensitive areas should not be diverted by the Project.

The Project will adhere to the City of Santa Cruz's Post Construction Storm Water Management Program and the County of Santa Cruz's *Design Criteria*. The goal of the City of Santa Cruz's Post Construction Storm Water Management Program is to minimize the alteration of natural watercourses and drainage patterns, minimize impact to the site's natural topography and vegetation, and minimize long-term impacts on storm water quality from post-construction runoff. Minimization of the alteration of natural watercourses and drainage patterns can be achieved with detention devices. The Project's design goal will be to maintain pre-construction storm water discharge flows by metering or detaining these flows to pre-construction rates prior to discharge to a receiving water body or Municipal Separate Storm Sewer System.

1.11 Agencies Impacting Design

As previously noted, the Project is located in the cities of Santa Cruz and Soquel. Any drainage improvements proposed for the local roads that are impacted by the Project, and any other off-site drainage systems impacted by the Project will conform to these local agency requirements.

Due to potential impacts to water resources within the Project limits, the Project Team will have to address concerns from regulatory agencies. The main areas where potential water quality impacts may occur are within the creeks crossing Highway 1, and the biotic/aquatic or wetland areas adjacent to creek crossings and parallel to Highway 1. Surface water resources within the Project limits are under the jurisdiction of the United States Army Corp of Engineers, the Central Coast Regional Water Quality Control Board, and the California Department of Fish and Game. Consultation with the National Oceanic and Atmospheric Administration National Marine Fisheries Service is anticipated.

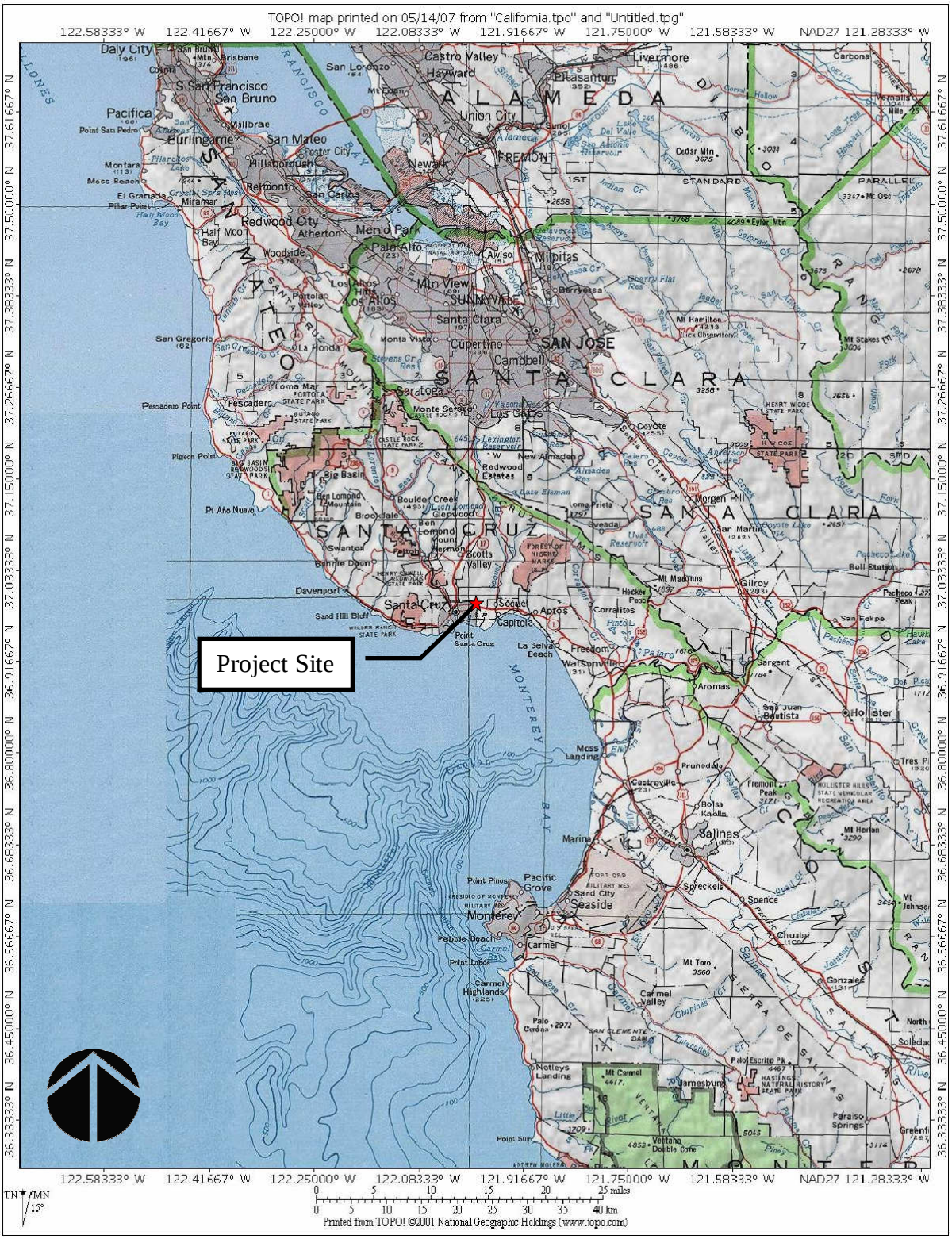


Figure 1. Vicinity Map

Source: United States Geological Survey

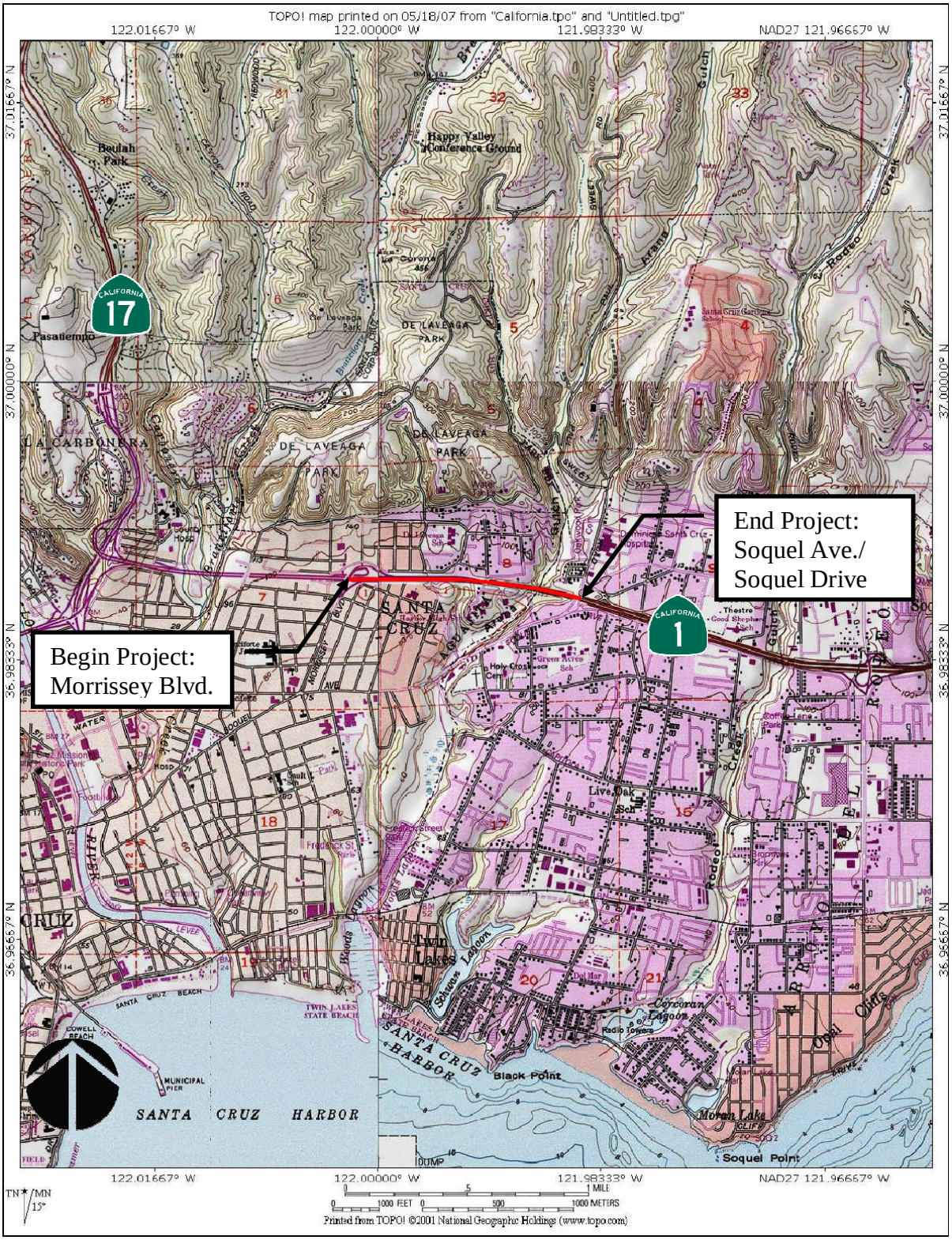


Figure 2. Location Map

Source: United States Geological Survey

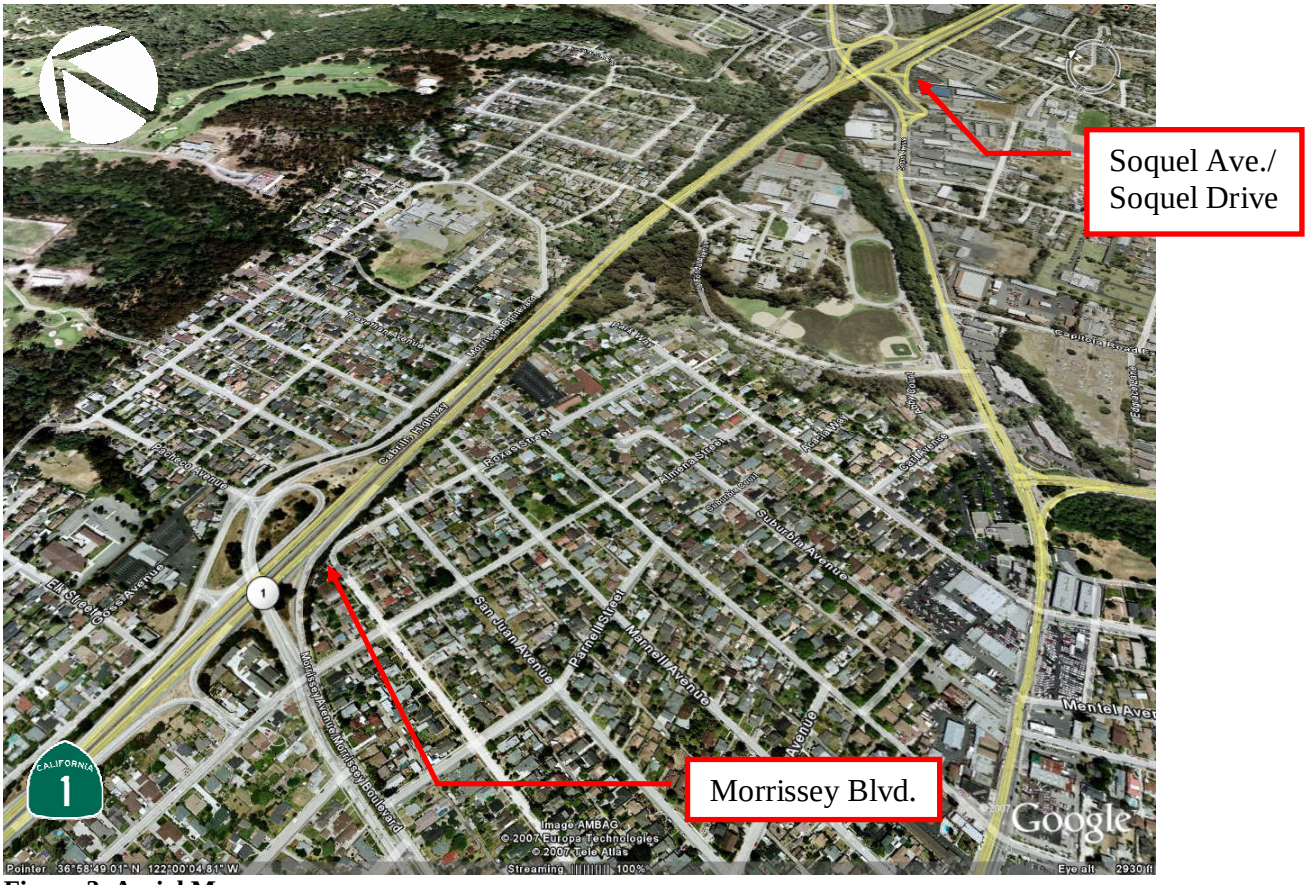


Figure 3. Aerial Map

Source: Google Earth Image (Google Last Accessed: November 16, 2007)

2 OFF-SITE HYDROLOGY

2.1 Regional Hydrology

The Project is under the jurisdiction of the Central Coast Regional Water Quality Control Board. The hydrology along Highway 1 is controlled by existing creeks and drainages, with extensive runoff contribution from urban and residential development, roadways, and parking areas. Highway 1 crosses several large watersheds and most of the creeks and drainages it crosses flow directly to the Pacific Ocean, downstream of the Project. The Project is located in the San Lorenzo watershed according to the Santa Cruz Watersheds Map and the California Watershed Portal Tool (used as a reference tools to develop a map by overlaying the two maps onto the United States Geological Survey topographic map). No tidally influenced or brackish areas are present within the Project area (Morro Group, 2008, pg. 20). The San Lorenzo watershed (Hydrologic Sub-Area 304.12), The San Lorenzo Hydrologic Sub-Area is in the Santa Cruz Hydrologic Area and in the Big Basin Hydrologic Unit (California State University Sacramento, Office of Water Programs, Water Quality Planning Tool).

2.2 Local Hydrology

The major drainage basin in the Project area is the San Lorenzo basin and Arana Gulch is the subbasin. Figure 8 depicts the location of the Project relative to the San Lorenzo watershed and the Arana Gulch sub basin. Figure 9 shows the local hydrology.

Drainage basins in Santa Cruz County are short and steep with short flow durations. Mountains and hills bordering the eastern boundaries of Santa Cruz County squeeze moisture out of arriving Pacific weather systems and provide watershed areas to funnel precipitation into runoff tributaries.

The following descriptions of creek crossings and channels are from the *Wetland Assessment* by Morro Group (2008).

> "The portion of Arana Gulch assessed consists of a broad, slightly incised channel in an urban setting dominated by California Bay, Eucalyptus, Redwood, Coast Live Oak, California Blackberry, Poison Oak, Stinging Nettle, Box Elder, and Arroyo Willow. Natural channel areas exhibit a clay or sand bottom averaging 3 to 6.1 meters (10 to 20 feet) wide at the Ordinary High Water Mark, which is approximately 0.7 meters (2.5 feet) above the thalweg. This creek receives runoff from a large urban watershed area, including several tributary channels. Tributary channels to Arana Gulch are fed by residential runoff and highway drop inlets from the south of the Project area."

2.3 Watershed and Basin Characteristics

Runoff within the Project limits flows south to Monterey Bay (and eventually to the Pacific Ocean). All cross drainages convey flow directly south to Monterey Bay. North

of this segment lies De Laveaga Park, which is located at the northern limit of the watershed.

Off-site watersheds for the Project are delineated in

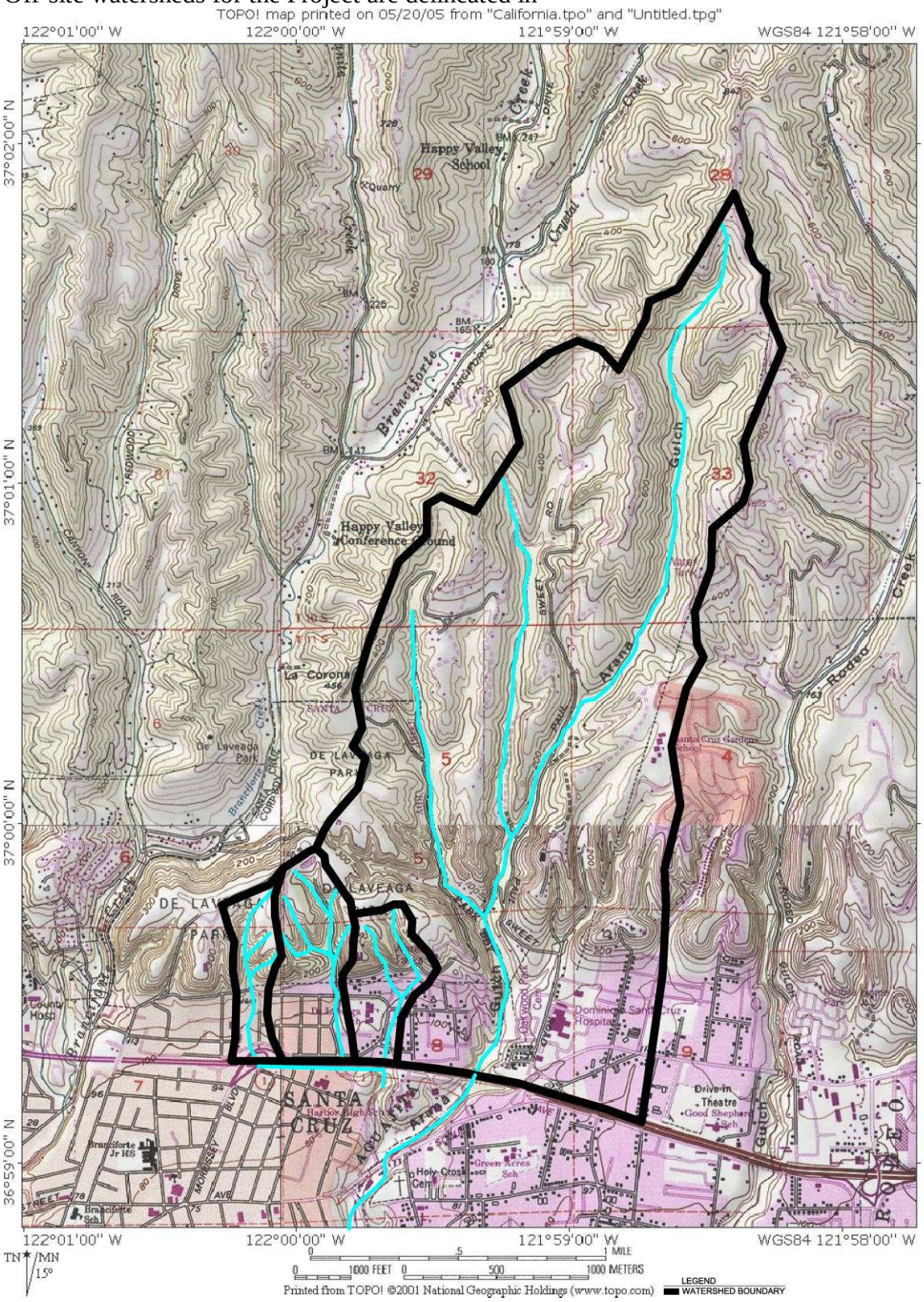


Figure 4. The existing drainage facilities for major crossings within the Project limits are summarized in Table 1.

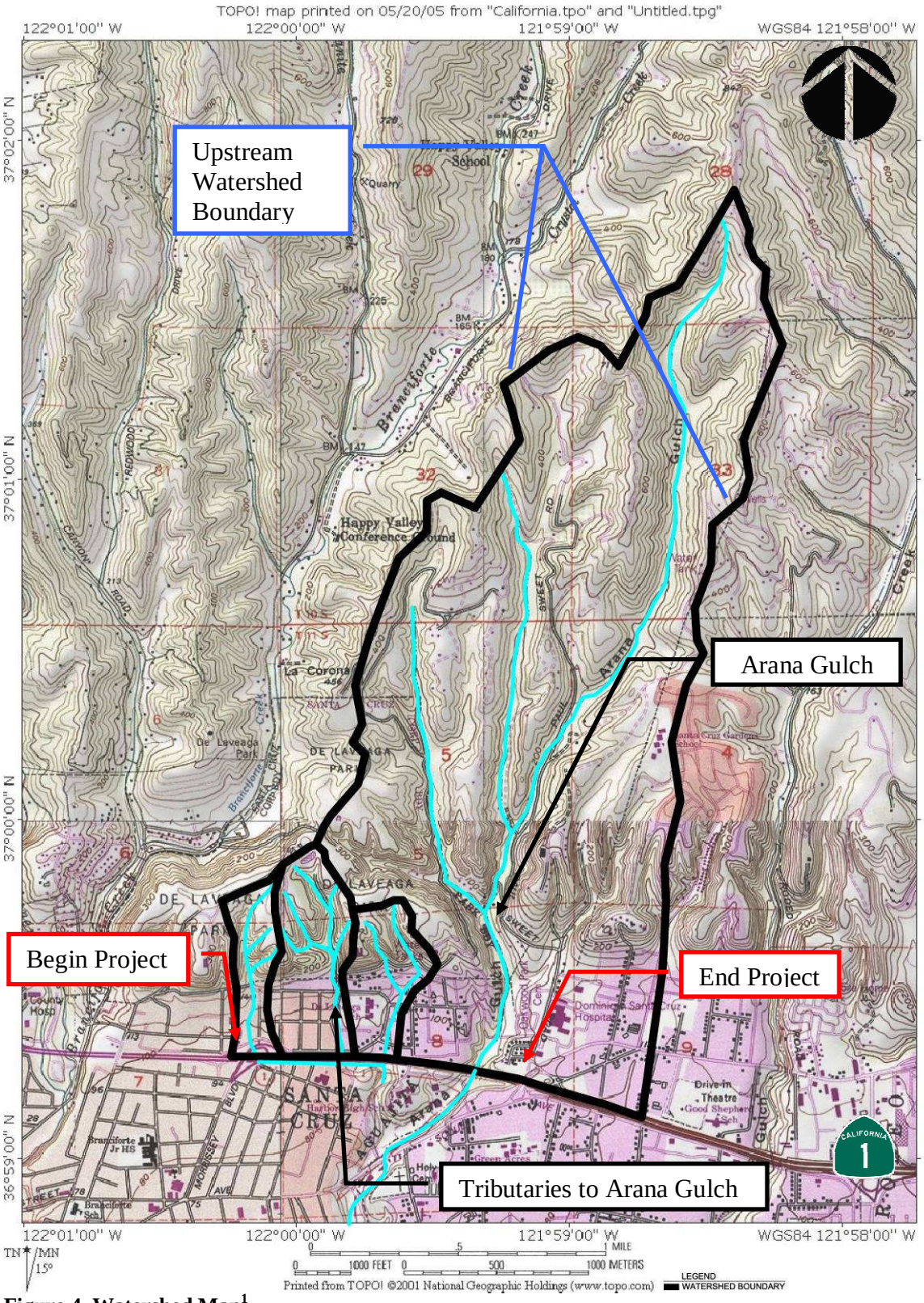


Figure 4. Watershed Map[1]

[1] Note: Figure 4. Watershed Map shows only tributary delineation for flow upstream of the Project.

Source: United States Geological Survey

2.4 Estimating Design Discharge

Peak discharge for Arana Gulch was obtained from the Federal Emergency Management Agency Flood Insurance Study. The drainage area at the mouth of Arana Gulch is approximately 3.5 square miles (9.1 square kilometers), with the 100-year peak discharge as 1,650 cfs (46.7 m^3/s) (Federal Emergency Management Agency, 1986).

Peak discharges for the tributaries to Arana Gulch were estimated using United States Geological Survey Regional Flood-Frequency Equations (Waananen & Crippen, 1977). The Regional Flood-Frequency Equation for the Central Coast Region is expressed as:

$$Q_{100} = 19.7 A^{0.88} p^{0.84} H^{-0.33}$$

Where:

Q = Peak discharge in cubic feet per second, with subscript indicating recurrence interval, in years;

A = Drainage area in square miles;

p = Mean annual precipitation in inches;

H = Altitude index in thousands of feet: the average of the elevations at the locations 10% and 85% of the distance from the Project site to the basin divide, measured along the main channel of the stream and the overland travel path to the basin divide.

Drainage area and altitude index were determined by delineating watersheds (shown in

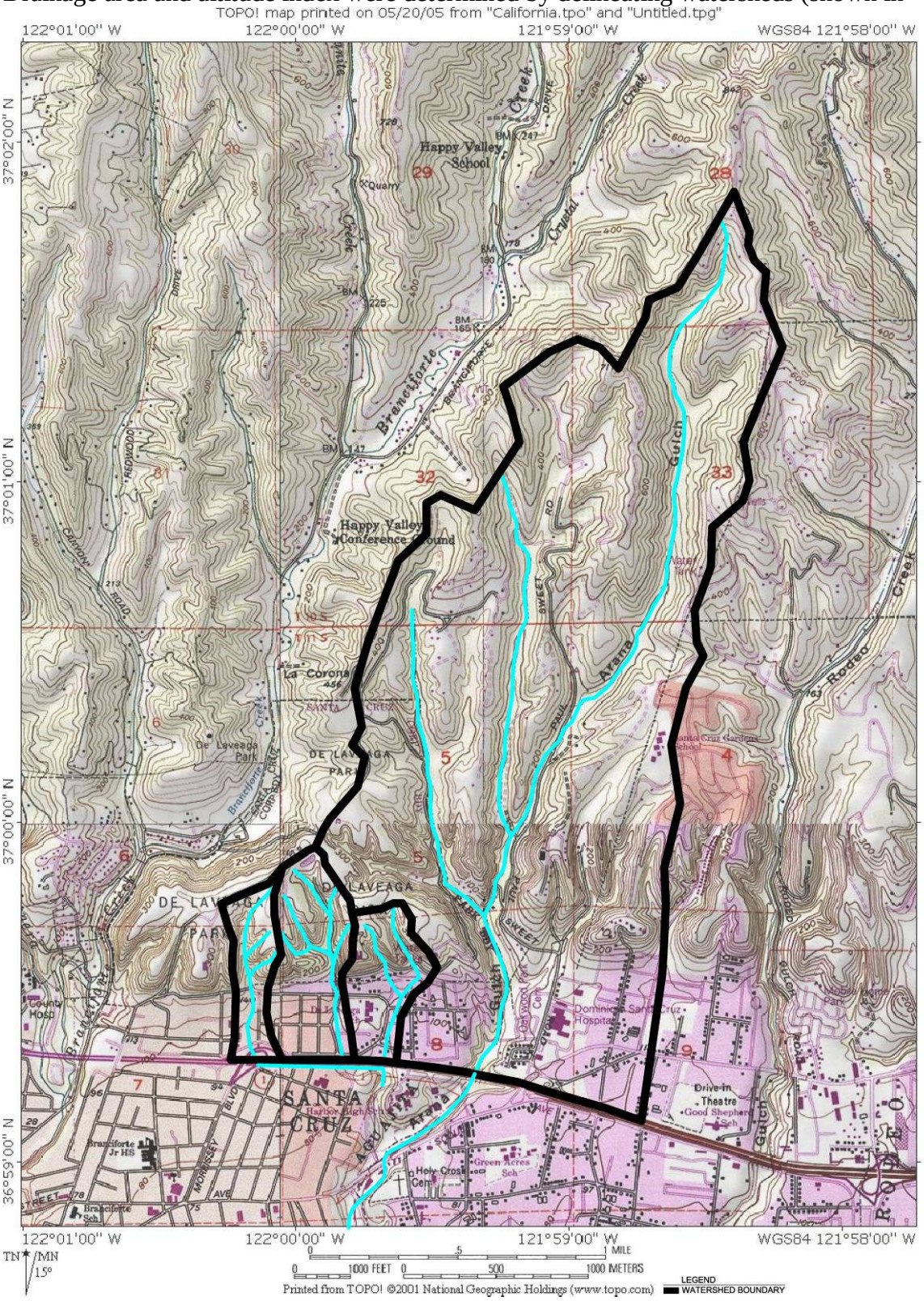


Figure 4) for each crossing of interest. Mean annual precipitation values were obtained from Spatial Climate Analysis Parameter-elevation Regressions on Independent Slopes Model mapping data (Oregon State University Spatial Climate Analysis, 2003).

Headwater depths were determined using culvert design charts (Federal Highway Administration, 2001) with design discharges and known culvert sizes. The upstream water surface elevation is the sum of this value and the elevation at the culvert at the inlet.

2.5 Rainfall Data and Intensities

Santa Cruz County has a Mediterranean climate with low humidity and sunshine about 300 days a year. The general climate pattern at the Project area is characterized by relatively stable temperatures year round, with an average temperature in the range of 50ºF to 65ºF (10˚C to 18.3˚C).

In the southern part of the area, the mean annual precipitation is between 25 to 28 inches (63.5 to 71.1 centimeters), the mean annual air temperature is 58°F (25.4˚C), and the frost-free season is between 245 and 275 days. The part of the Project area near Aptos has a mean annual precipitation of 29 inches (73.7 centimeters), a mean annual temperature of about 58°F (25.4˚C), and the frost-free season ranges from 245 to 275 days (United States Department of Agriculture - Natural Resources Conservation Service, 2007).

Marine influence and buffering from mountains contribute to moderate temperatures. The wet season is from October to May (official rainy season is October 15 to April 15). Most flood-producing rainfall happens between December and March. Snowfall is infrequent (Federal Emergency Management Agency, 1986).

The design rainfall intensities are estimated using the County of Santa Cruz's *Design Criteria*. The equations given to find the intensities for a 25-year storm event are as follows:

$$Intensity = 1.20 \times \frac{4.29112 \times 1.195^{P_{60}}}{Duration^{0.60924 \times 0.78522^{P_{60}}}}$$

Where:

Intensity =	Rainfall Intensity for a given storm event (inches/hour)
Duration =	Duration of given storm event (minutes)
P_{60} =	Rainfall intensity for 60-minute duration and a 100-year storm obtained from the isopleths for Santa Cruz County. (inches/hour)

This intensity equation is based on the 10-year intensity equation given by the *Design Criteria*. It can be used to get the desired storm event if multiplied by the specified factor. In this case, the multiplier for a 25-year storm event is 1.20. With a P_{60} of 1.50 inches/hour for a storm duration of 10 minutes, the intensity is 2.11 inches/hour for a 10-

year storm; it is 2.54 inches/hour for a 25-year storm; and it is 3.17 inches/hour for a 100-year storm (County of Santa Cruz, June 2006).

The Rainfall Intensity plots and the isopleths for Santa Cruz County are included in Appendix A.

Rainfall intensity was also compared with the Intensity-Duration-Frequency chart from the Federal Highway Administration's HYDRO program. In most cases, the intensity based on the County of Santa Cruz's *Design Criteria* is more conservative. The 10-year and 25-year return periods for a 5-minute duration storm are more conservative if the results from HYDRO are used. A comparison of the Intensity-Duration-Frequency for the two methods is in Appendix A. In the final design phase of the Project, the Design Team will decide which rainfall intensities to employ for the drainage design.

2.6 Points of Concentration and Outfalls

The points of concentration for the Project are defined at the upstream end of the cross culverts. The outfalls are defined at the point of discharge of the cross culverts.

3 OFF-SITE HYDRAULICS

The objective of the drainage design is to limit the design water surface elevations and velocities to no greater than the existing conditions and to maintain the existing drainage pattern.

New cross drainage systems will be designed to convey the 100-year storm event without objectionable backwater and pass the 10-year storm within the culvert cross section, as required in the *Highway Design Manual*. Existing cross culvert systems that are capable of passing the 10-year event and the 100-year event without objectionable backwater and that are in good conditions will be proposed to remain in place.

The existing 4 feet by 4 feet (1200 mm by 1200 mm) reinforced concrete box culvert at Station 177+92 is undersized and this will be addressed by proposing drainage improvements. For example, the addition of a culvert, or culverts, parallel to the existing culvert will help to increase the drainage capacity at this crossing. The discharge at the downstream side of the cross culvert(s) should be metered or detained to pre-construction rates prior to discharging to the downstream receiving water body. The proposed culvert(s) will be alternative pipe culverts. The condition of the cross culverts is unknown due to the heavy vegetation blocking access to the culvert entrance and outfalls. The condition of the culverts will need to be evaluated in the final design phase. Culverts that are in poor condition will need to be replaced with alternative pipe culvert, as necessary.

The cross culvert drainage systems used for conveying off-site runoff were studied with available information to determine their capacity for the 10- and 100-year peak flows but should be re-evaluated pending additional survey information. The existing capacity for the culvert crossings was determined by comparing the elevation of the roadway to the water surface elevations corresponding to a 100-year peak discharge. The water surface elevations upstream and downstream of the Highway 1 crossing of Arana Gulch (Station 171+03) were obtained from the Federal Emergency Management Agency Flood Insurance Rate Map. The upstream water surface elevation for the tributaries to Arana Gulch at Station 175+98 and Station 177+92 were calculated as described in Section 2.4 of this report. Downstream water surface elevations for these two tributaries to Arana Gulch (at Station 175+98 and Station 177+92) were not available from the Federal Emergency Management Agency Flood Insurance Rate Maps; these fields are indicated with “N/A” in Table 2, following. The water surface elevation for the tributary to Arana Gulch at Station 183+01 was not calculated because no improvements will occur for the area draining to this waterway.

Table 2. Hydraulic Data

Reach	100-Year Peak Discharge (cfs)	Drainage Area (mi^2)	Upstream Water Surface Elevation (ft)	Downstream Water Surface Elevation (ft)	Culvert Capacity
Arana Gulch at Station 171+03	1,650	3.5	65	46	Sufficiently sized to pass 100-year design discharge
Tributary to Arana Gulch at Station 175+98	100	0.11	73	N/A	Sufficiently sized to pass 100-year design discharge
Tributary to Arana Gulch at Station 177+92	145	0.17	92	N/A	Culvert is undersized
Tributary to Arana Gulch at Station 183+01	71	0.08	Not calculated since Project will not impact this crossing		

The hydraulic regime for most creek crossings at Highway 1 is upstream controlled. The Federal Emergency Management Agency Flood Insurance Study documents debris buildup and ponding during past, severe storm events. Debris buildup and ponding has the potential to occur at the upstream end of the culverts which could attenuate peak flows.

The 4 feet by 4 feet (1200 mm by 1200 mm) reinforced concrete box culvert at the tributary to Arana Gulch (Station 177+92) is undersized; based on the preliminary hydraulic calculations, the water surface elevation will be higher than the roadway surface. WRECO recommends that drainage improvements be implemented to address existing capacity issues while also trying to maintain existing flow rates. For example, additional culverts can be added parallel to the existing cross culvert. Analysis for the 25-year storm was used in making recommendations for the 4 feet by 4 feet (1200 mm by 1200 mm) reinforced concrete box culvert improvements. The Caltrans 100-year storm criteria for the design of cross culverts may be deemed infeasible due to environmental concerns in the Project area. The downstream end of the culvert is within both Army Corps of Engineers and California Department of Fish and Game jurisdictional wetlands. Caltrans will make the final decisions on the drainage improvements for this Project based on two factors: 1) serving the needs and purpose of the Project and 2) minimizing environmental impacts.

The additional discharge that would be conveyed downstream should be metered such that pre-construction flows meet post-construction flows. A detailed analysis of the drainage improvements will be made during the final design phase when survey data will be available. See Appendix B for the locations of the proposed drainage improvements.

3.1 Culvert Material

New culverts will be specified as alternative pipe culvert. List of allowable material will be specified in the Contract Documents per recommendation from the Materials Report during the final design phase of the Project.

3.2 Inlet and Outlet Treatment and Energy Dissipation

The *Hydraulic Engineering Circular* No. 14, Hydraulic Design of Energy Dissipaters for Culverts and Channels (Federal Highway Administration, 1983) and the Rock Energy Dissipater at Culvert Outlet (Caltrans District 1, August 1999) will be used as guidelines for energy dissipation requirements for the inlets and outlets of each cross culvert. The California Bank and Shore Rock Slope Protection Design, published by Caltrans, should be used when determining rock size and placement for inlet and outlet treatment.

Rock slope protection is recommended at culvert entrances and outfalls to prevent scour and erosion. Typical inlet and outlet treatments for cross culverts are either flared end sections or standard Caltrans headwalls, and they will be specified during the final design phase on Project Drainage Plans.

The drainage design will be such that the alteration of natural watercourses and drainage patterns is minimized. This can be achieved with the implementation of detention devices. The Project will adhere to the City of Santa Cruz's Post Construction Storm Water Management Program and the County of Santa Cruz's *Design Criteria*.

4 ONSITE ROADWAY DRAINAGE

Calculations for the design of onsite drainage systems will be finalized during the final design phase pending more complete survey data or as-built information.

The build alternative will have sound walls, retaining walls, and gutters installed along the Project limits. These structures will impact existing drainage facilities within the edge of shoulders or may create new concentrated flows that warrant the need for new drainage systems. See Appendix B for the locations of the potential proposed longitudinal drainage systems. In general, new longitudinal systems are proposed in front of retaining walls: from Station 170+50 to Station 176+38 in the southbound direction and from Station 170+71 to Station 176+50 in the northbound direction. New outfalls, or connections, are proposed to tie the new longitudinal systems to the existing cross culverts. Other areas where drainage systems may need to be proposed will be at the areas where Best Management Practices are proposed: from Station 171+69 to Station 172+79 in the southbound direction and near the Morrissey Boulevard interchange. The drainage systems will be designed to route flows to the Best Management Practices. The proposed Best Management Practices are shown in the *Storm Water Data Report* (WRECO, 2008).

Analysis will be done during the PS&E phase to determine the need for longitudinal systems near these structures to accommodate the flows. Existing longitudinal systems will also be evaluated to ensure that new flows can be accommodated per Caltrans' Highway Design Manual.

4.1 Recurrence Interval

The Project site is a multi-lane highway with speeds over 45 mph (75 kph). According to Table 831.3 of the Highway Design Manual, the design storm is a 25-year storm. The design water spread can not spread onto the travel way. According to Section 831.4 of the Highway Design Manual, no more than 0.1 cfs (0.003 m^3/s) of sheet flow should be allowed to flow across the roadway. Storm water flows will be concentrated in drainage ditches, roadside gutters, and along dikes, barriers, or retaining walls.

4.2 Grate Interception and Gutter Capacity

Spread width and inlet capacities will be estimated using the methods and procedures described in the Federal Highway Administration *Hydraulic Engineering Circular* No. 22, second Edition.

The allowable spread width will vary between 7.5 and 9.8 feet (2.4 and 3 meters) in both directions of travel, depending on the proposed shoulder width per location.

4.3 Storm Water Best Management Practices

The Project Team will consider storm water quality measures to address potential temporary and permanent water quality impacts of the Project, as defined in the Caltrans

Storm Water Quality Handbook, Project Planning and Design Guide (2003) for major reconstruction projects. The detailed plan for dealing with storm water quality for this Project can be found in the *Storm Water Data Report* for this Project (WRECO, 2008). This report includes Construction Site Best Management Practices, Design Pollution Prevention Best Management Practices, and Treatment Best Management Practices.

5 TEMPORARY DRAINAGE SYSTEMS

Temporary creek diversion plans or dewatering specifications are not anticipated since the channel may be dry during the construction period. However, if the creek is wet during construction, temporary drainage pipes or systems may be needed during the stage construction to maintain drainage flows. The design of the temporary drainage systems will begin after receipt of the detour and/or stage construction plans which are available during the final design phase.

6 FLOODPLAIN INFORMATION

The Federal Emergency Management Agency *Flood Insurance Rate Map for Santa Cruz County, Unincorporated and Incorporated Areas*, Map Number 06087C0351D, was reviewed for this Project. The Flood Insurance Rate Map indicates that delineated floodplains exist at the Arana Gulch crossing of Highway 1. The Flood Insurance Rate Map covering the Project limits is included in Appendix C. Detailed floodplain information can be found in the Project *Location Hydraulic Study Report* (WRECO, 2008).

7 COST ESTIMATE

The current total estimated cost (excluding right-of-way items) for the Project is estimated to be $14,184,000. The cost will be updated and revised as the Project progresses through the final design phase.

The construction cost for drainage improvements at this stage in the Project is anticipated to be $919,090. This cost includes proposed longitudinal drainage systems, cost of gutters and ditches, cross culvert adjustments, and improvements to existing drainage systems. Project construction costs for Best Management Practices are anticipated to be $275,727.

8 REFERENCES

California Department of Transportation. (2006). *Highway Design Manual*. Fifth Edition Metric.

California Department of Transportation. (January 26, 2007). *Preliminary Project Cost Estimate Summary*.

City of Santa Cruz. (2004). *Storm Water Management Program.* Chapter 6, "Post-Construction Storm Water Management Control Program." <http://www.ci.santa-cruz.ca.us/pw/Stormwater2004/> (Last Accessed: November 14, 2007).

County of Santa Cruz. (June 2006). *Design Criteria: Containing Standards for the Construction of Streets, Storm Water Systems, Sanitary Sewers, Water Systems, Driveways within the Unincorporated Portion of Santa Cruz County*.

Federal Emergency Management Agency, *Flood Insurance Rate Maps for Santa Cruz County, California (Unincorporated Areas)*. Community Panels 06087C0351D March 2, 2006.

Federal Emergency Management Agency, *Flood Insurance Study for Santa Cruz County, California (Unincorporated Areas)*. Community Number 060353, April 15, 1986.

Morro Group, Inc. (2008). *Highway 1 Soquel to Morrissey Auxiliary Lanes Project. Wetland Assessment*. Prepared for Parsons Transportation Group, 120 Howard Street, Suite 850, San Francisco, CA 94105. May 2008.

Parikh Consultants, Incorporated. (2005). *Preliminary Geotechnical Information (Foundation Type Selection), Highway 1 HOV Lane Widening Project, Morrissey Boulevard Overcrossing* (Br. No. 36-0066), Santa Cruz County, California. Structure Memorandums. Job Number 203132.10. Received from NOLTE 04/26/2006.

Parikh Consultants, Incorporated. (2005). *Preliminary Geotechnical Information (Foundation Type Selection), Highway 1 HOV Lane Widening Project, La Fonda Avenue Overcrossing* (Br. No. 36-0018), Santa Cruz County, California. Structure Memorandums. Job Number 203132.10. Received from NOLTE 04/26/2006.

United States Department of Agriculture, Natural Resources Conservation Service. Web Soil Survey. <http://websoilsurvey.nrcs.usda.gov/app/> (April 30, 2007).

United States Department of Transportation, Federal Highway Administration. (August, 2001). "Urban Drainage Design Manual." *Hydraulic Engineering Circular* No.22, FHWA-NHI-01-021.

United States Department of Transportation, Federal Highway Administration. (September, 2001)."Hydraulic Design of Highway Culverts." *Hydraulic Design Series* 5, FHWA-NHI-01-02.

United States Geological Survey. (2001). California: Seamless U.S.G.S. Topographic Maps [CDROM, Version 2.6.8, 2001, Part Number: 113-100-004]. National Geographic Holdings, Inc.

WRECO. (2008). *Location Hydraulic Study Report: Highway 1: Highway 1 Soquel to Morrissey Auxiliary Lanes Project*. Walnut Creek, CA. September 2008.

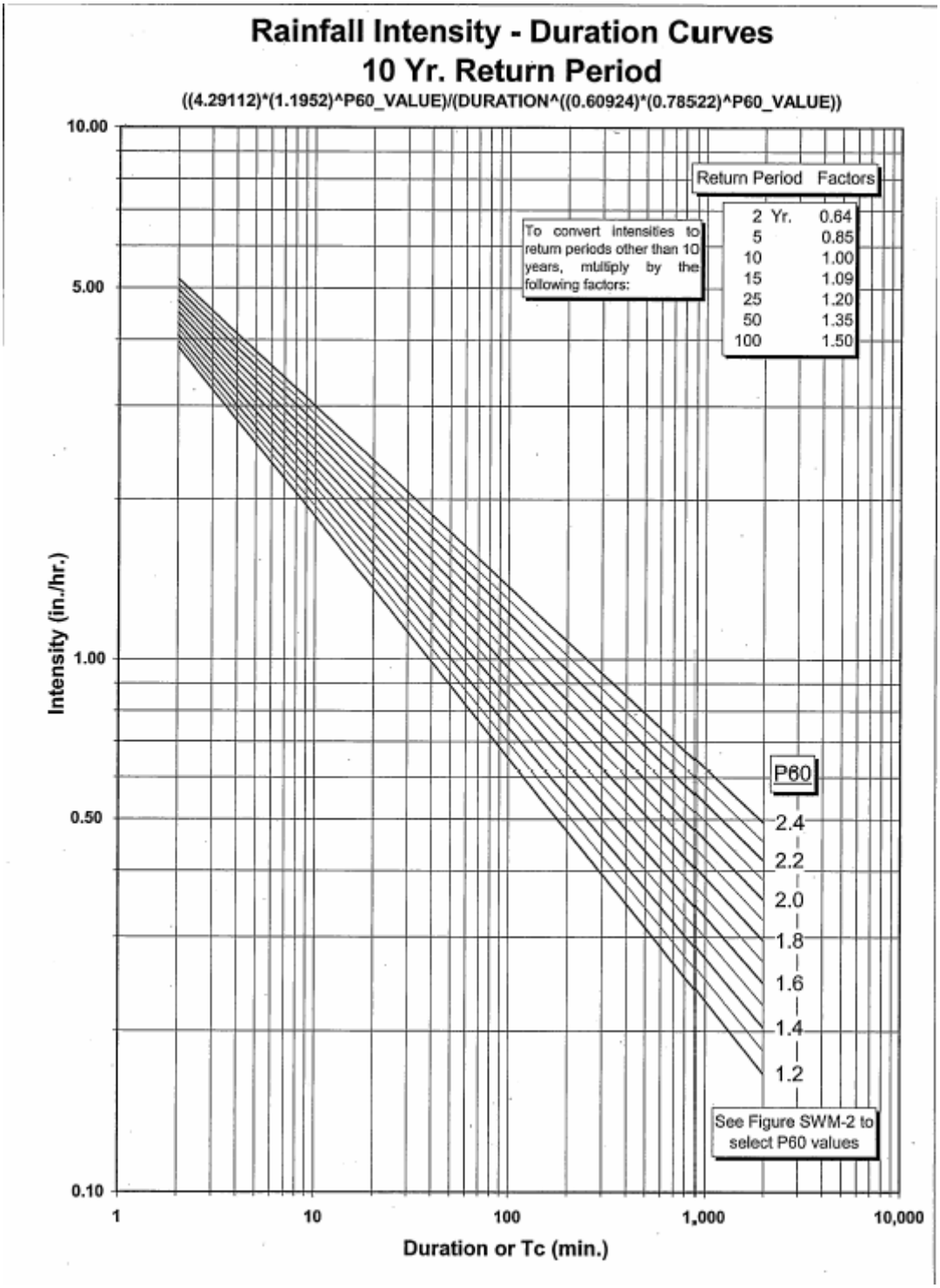
WRECO. (2008). *Storm Water Data Report: Highway 1: Highway 1 Soquel to Morrissey Auxiliary Lanes Project*. Walnut Creek, CA. September 2008.

WRECO. (2008). *Water Quality Study Report: Highway 1: Highway 1 Soquel to Morrissey Auxiliary Lanes Project*. Walnut Creek, CA. September 2008.

Appendix A Hydrologic Data

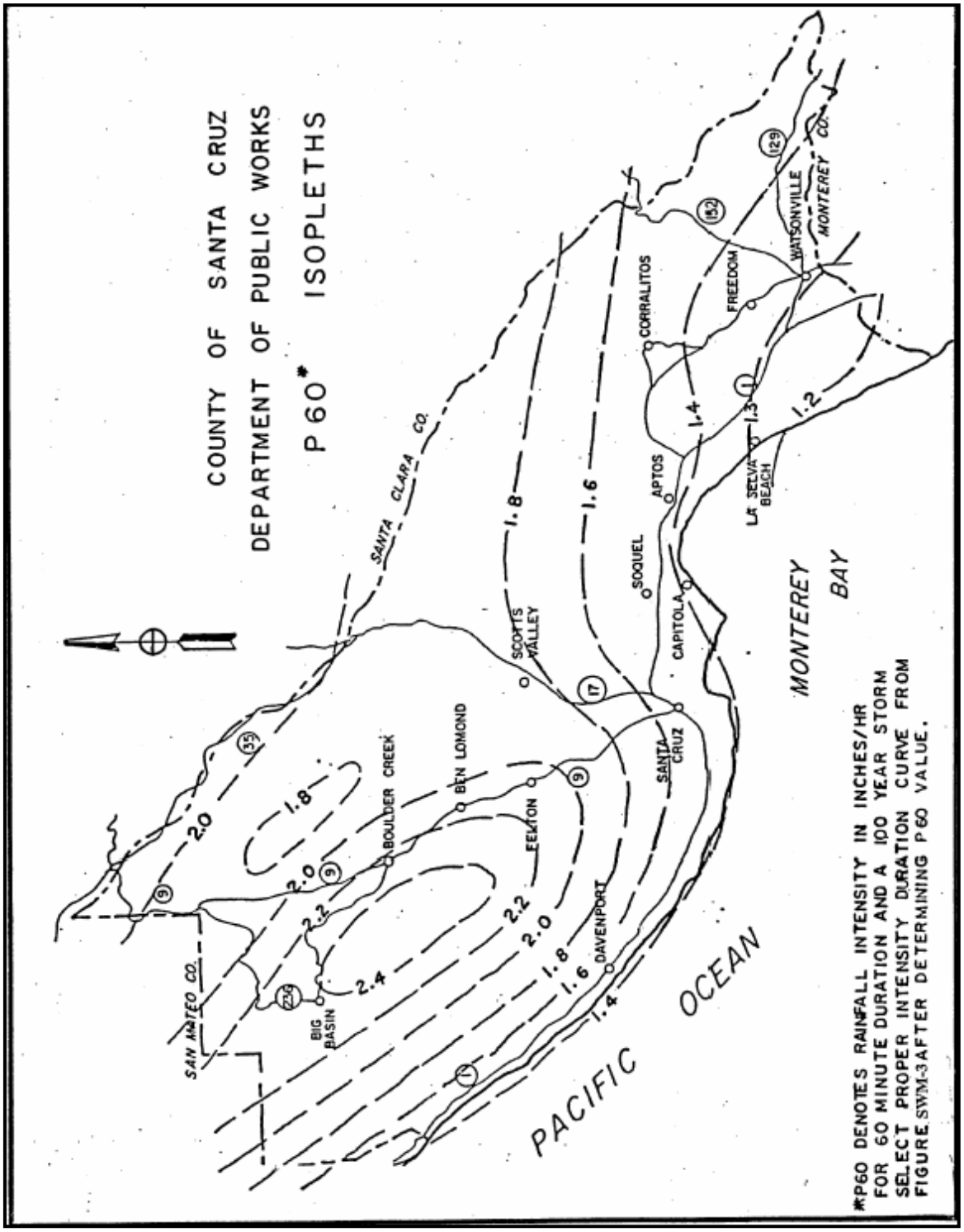
County of Santa Cruz Rainfall Intensity Curve
County of Santa Cruz Isopleths
HYDRO Intensity-Duration-Frequency
Rainfall Intensity Comparison

Appendix A.1 County of Santa Cruz Rainfall Intensity Curve



Source: County of Santa Cruz , June 2006

Appendix A.2 County of Santa Cruz Isopleths



Appendix A.3 HYDRO Intensity-Duration-Frequency

```
               *************** HYDRO - Version 6.1 ***************
               *  HEC19 / Design Event vs Return Period Program  *
               *              Date of Run: 11-06-2007            *
                                                                  Page No  1
                    Soquel to Morrissey Auxiliary Lane Project

--- Input File: C:\HYDRO\P0604(E).HDO

 IDF

 === IDF CURVE Option Selected ...

 CAL rain95.asc

 === File Read from Intermediate Directory: rain95.asc

 RPD 2

--- The Selected Return Period is    2 years.

 LOC 36 52 121 60

--- The Latitude is 36 degrees, 52 minutes.
--- The Longitude is 121 degrees, 60 minutes.

 STA D007616050
 STA D007916000
 STA D108680000
 STA D002048000

 +++ End of HYDRO Command File



--- The Following Stations are within ñ0.25 degrees Lat/Long of the Site:

    Station ID   Elev. (ft)   Lat/Long (dec. deg.)  Distance from Site (miles)

    D000674050    400           37.090  122.080               15.9
    D002048000    260           36.983  121.800               13.5
    D002290050    100           37.017  122.200               15.0
    D007616050     60           36.967  121.967                7.0
    D007916000    125           36.983  122.017                8.0
    D008372030    360           37.058  121.924               13.7
    D103232000   1495           37.050  121.817               16.1
    D108680000     85           36.900  121.833                9.3
    D201586025     13           36.767  121.767               14.5
    E605058001   3789           37.111  121.843               18.9

--- The Following Station(s) Will Be Used in Determining the Sites Intensity:
    Station ID   Elev. (ft)   Lat/Long (dec. deg.)  Distance from Site (miles)

    D007616050     60           36.967  121.967                7.0
    D007916000    125           36.983  122.017                8.0
    D108680000     85           36.900  121.833                9.3
    D002048000    260           36.983  121.800               13.5

    Notice:  A Station Elevation of -999 Indicates A Missing Value.
```

```
                ***** HYDRO ***** (Version 6.1) *****         Date 11-06-2007
                                                                   Page No  2
                   Soquel to Morrissey Auxiliary Lane Project

                      -----------------------------------
                      IDF Curve for Various Return Periods
                      -----------------------------------
                              Intensities (in/h)

 Duration        2 Yr    10 Yr      25 Yr      50 Yr     100 Yr   10000 Yr
 ------------------------------------------------------------------------------
  5 min         1.699     2.852      3.433      3.834      4.229      6.695
 10 min         1.242     2.085      2.510      2.803      3.092      4.895
 15 min         1.035     1.736      2.090      2.335      2.575      4.076
 30 min          .757     1.270      1.529      1.707      1.883      2.981
 60 min          .553      .929      1.118      1.249      1.377      2.180
120 min          .405      .679       .817       .913      1.007      1.594
  4 h             .296      .497       .598       .668       .736      1.166
  8 h             .216      .363       .437       .488       .539       .853
 16 h             .158      .266       .320       .357       .394       .624
 24 h             .132      .221       .266       .297       .328       .519
 ------------------------------------------------------------------------------

                ***** HYDRO ***** (Version 6.1) *****         Date 11-06-2007
                                                                   Page No  3
                   Soquel to Morrissey Auxiliary Lane Project



                     Intensity Curve for    2 Year Return Period
                     Rainfall Intensity (in/h) versus Duration (h)

    1.70*.....................................................................
        .                                                                    .
        .                                                                    .
        .                                                                    .
    1.27.                                                                    .
        *                                                                    .
        .                                                                    .
        .*                                                                   .
        .                                                                    .
     .85.                                                                    .
        .                                                                    .
        .*                                                                   .
        .                                                                    .
        .  *                                                                 .
     .42.     *                                                              .
        .                                                                    .
        .          *                                                         .
        .                     *                     *                      .
        .                                                                   *
     .00.....................................................................
        .00             6.00            12.00           18.00           24.00


 +++ Notice:  Intermediate file has English units.

 === File Created on Intermediate Directory: P0604(E).IDF

 +++ NORMAL END OF HYDRO
```

Appendix A.4 Rainfall Intensity Comparison

		Intensity, i, in/hr for Return Period					
Duration, D		HYDRO			Santa Cruz County		
min	hour	10-Year	25-Year	100-Year	10-Year	25-Year	100-Year
5	0.08	2.852	3.433	4.229	2.024	2.429	3.036
10	0.17	2.085	2.51	3.092	2.449	2.939	3.674
15	0.25	1.736	2.09	2.575	2.739	3.286	4.108
30	0.5	1.27	1.529	1.883	3.313	3.976	4.970
60	1	0.929	1.118	1.377	4.009	4.811	6.014
120	2	0.679	0.817	1.007	4.853	5.824	7.280
240	4	0.497	0.598	0.736	5.870	7.044	8.804
480	8	0.363	0.437	0.539	7.106	8.527	10.658
960	16	0.266	0.32	0.394	8.591	10.309	12.887
1440	24	0.221	0.266	0.328	9.615	11.538	14.423

Appendix B Drainage Improvement Locations

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No	TOTAL SHEETS
05	SCr	1			

REGISTERED CIVIL ENGINEER

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER
CHRISTOPHER P. METZGER
No. 40947
Exp. 3-31-07
CIVIL
STATE OF CALIFORNIA

WRECO
1243 Alpine Road, Suite 108
Walnut Creek, CA 94596

Caltrans Metric

DESIGN OVERSIGHT

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

Caltrans

DATE	REVISED BY	DATE REVISED

CALCULATED/ DESIGNED BY

CHECKED BY

LA FONDA AVENUE OVERCROSSING

HIGHWAY 1

ARANA GULCH

171+00 172+00 173+00 174+00 175+00 176+00 177+00 178+00

LEGEND:

DRAINAGE IMPROVEMENT AREAS

EXISTING STORM DRAIN

NOTES:
1. LONGITUDINAL SYSTEMS ARE PROPOSED RUNNING ROUGHLY PARALLEL TO THE PROPOSED RETAINING WALLS.

2. DRAINAGE CONNECTIONS ARE PROPOSED WHERE THE PROPOSED LONGITUDINAL SYSTEMS WILL CROSS THE EXISTING CROSS CULVERTS.

ALL DIMENSIONS ARE IN METERS, UNLESS OTHERWISE SHOWN.

HIGHWAY 1 SOQUEL TO MORRISSEY AUXILIARY LANES PROJECT PROPOSED DRAINAGE IMPROVEMENT LOCATIONS SEPTEMBER 2008

SCALE: N.T.S.

DRN-1

MATCHLINE - SEE DRN-2

LAST REVISION

DATE PLOTTED => 11/14/07
TIME PLOTTED => 3:57:24 PM

FOR REDUCED PLANS ORIGINAL SCALE IS IN MILLIMETERS 0 20 40 60 80

USERNAME =>
DGN FILE => ..\P0604 SR1Aux\dwg\bs DRN.DWG

CU

EA

EXMA, extol2, extol1, extl, prma, EXIT, prpe83, TBCT, Weldel 5-9-07, PRPN_SQL-MRRSSY_A12

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No	TOTAL SHEETS
05	SCr	1			

REGISTERED CIVIL ENGINEER

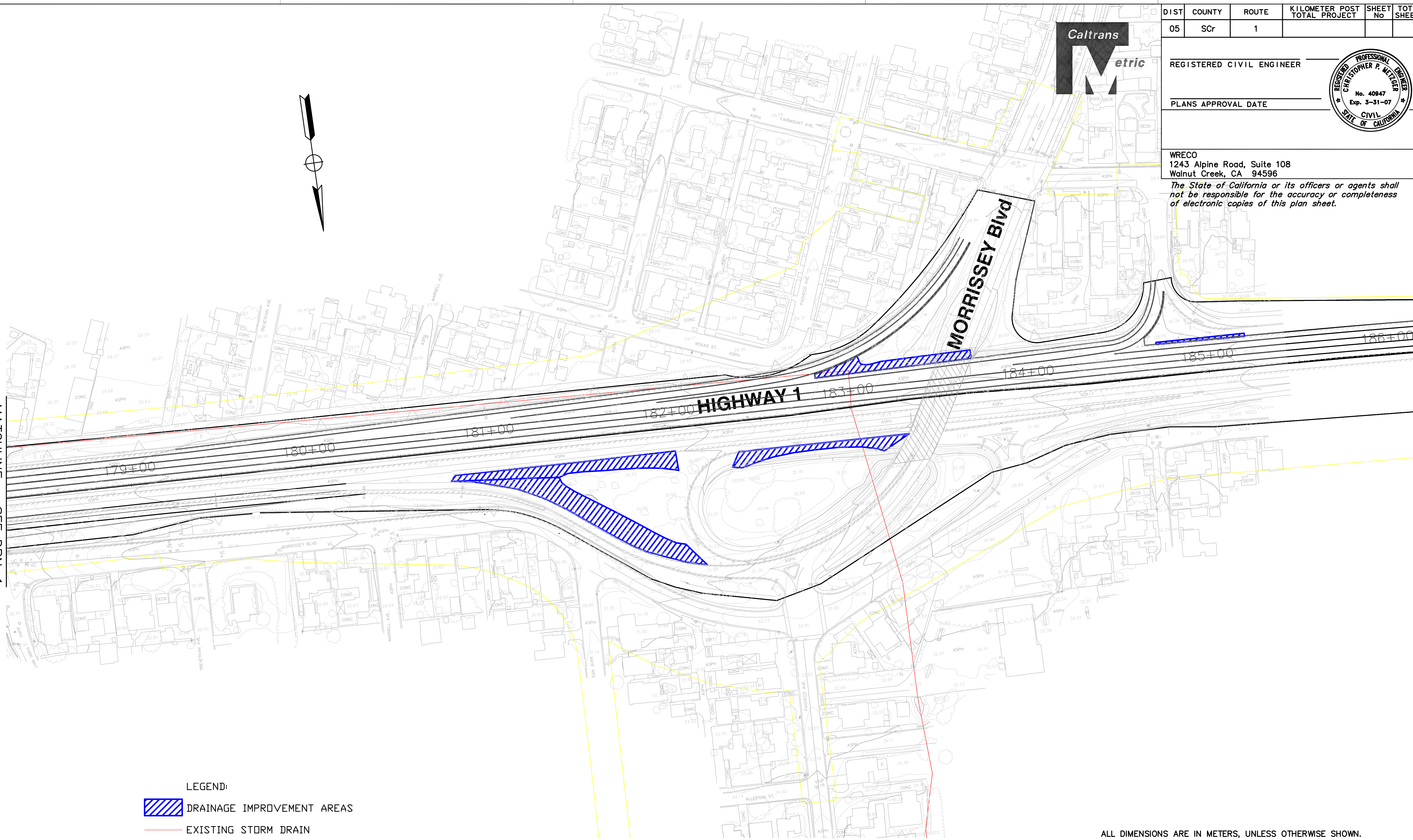
PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER CHRISTOPHER P. METZGER No. 40947 Exp. 3-31-07 CIVIL STATE OF CALIFORNIA

WRECO
1243 Alpine Road, Suite 108
Walnut Creek, CA 94596

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

Caltrans Metric



LEGEND:

DRAINAGE IMPROVEMENT AREAS

EXISTING STORM DRAIN

NOTES:
1. LONGITUDINAL SYSTEMS ARE PROPOSED RUNNING ROUGHLY PARALLEL TO THE PROPOSED RETAINING WALLS.

2. DRAINAGE CONNECTIONS ARE PROPOSED WHERE THE PROPOSED LONGITUDINAL SYSTEMS WILL CROSS THE EXISTING CROSS CULVERTS.

ALL DIMENSIONS ARE IN METERS, UNLESS OTHERWISE SHOWN.

HIGHWAY 1 SOQUEL TO MORRISSEY AUXILIARY LANES PROJECT PROPOSED DRAINAGE IMPROVEMENT LOCATIONS SEPTEMBER 2008

SCALE: N.T.S.

DRN-2

DATE PLOTTED => 11/14/07
TIME PLOTTED => 4:01:04 PM

LAST REVISION

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

DESIGN OVERSIGHT

CALCULATED/DESIGNED BY

CHECKED BY

REVISED BY

DATE REVISED

DATE

EXMA, exto12, exto11, exto, prma, EXUT, propeB3, TBCT, Wetdel 5-9-07, PRPN_SQL-MRRSSY_AU2

Caltrans

FOR REDUCED PLANS ORIGINAL SCALE IS IN MILLIMETERS

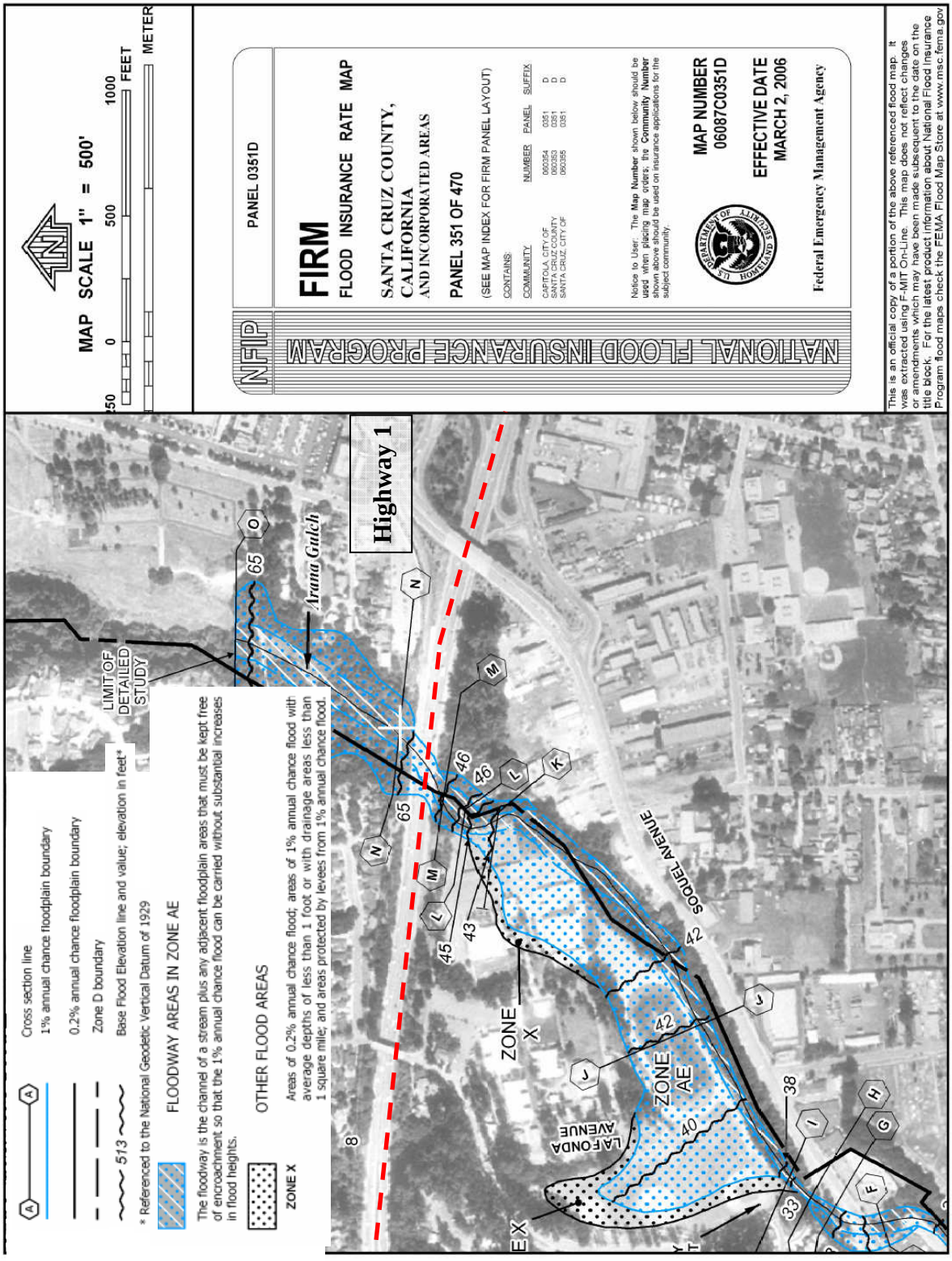
0 20 40 60 80

USERNAME =>
DGN FILE => ..\P0604 SR1Aux\dwg\bs DRN.DWG

CU

EA

Appendix C Federal Emergency Management Agency Flood Insurance Rate Map – Arana Gulch 100-Year Floodplain


NFIP
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
SANTA CRUZ COUNTY, CALIFORNIA
AND INCORPORATED AREAS
PANEL 351 OF 470
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
CAPITOLA, CITY OF 060354 0351 D
SANTA CRUZ COUNTY 060353 0351 D
SCOTTS VALLEY, CITY OF 060356 0351 D
Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.
MAP NUMBER
06087C0351D
EFFECTIVE DATE
MARCH 2, 2006
Federal Emergency Management Agency
PANEL 0351D
MAP SCALE 1" = 500'
0 500 1000 FEET
0 150 300 METERS
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov
Cross section line
1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Zone D boundary
513
Base Flood Elevation line and value; elevation in feet*
* Referenced to the National Geodetic Vertical Datum of 1929
FLOODWAY AREAS IN ZONE AE
The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.
OTHER FLOOD AREAS
ZONE X
Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.
LIMIT OF DETAILED STUDY
Highway 1
Arana Gulch
SOQUEL AVENUE
LA FONDA AVENUE
ZONE X
ZONE AE
EX
65
46
45
43
42
40
38
33
8

Appendix D Project Photographs

Photo 1. Tributary to Arana Gulch (Station 177+92) at Holway Drive crossing

Photo 2. Tributary to Arana Gulch (Station 175+98)

Photo 3. Arana Gulch (Station 171+03) downstream of Highway 1 crossing

Photo 4. Arch culvert at Arana Gulch (Station 171+03) downstream of Highway 1 crossing

Photo 5. Arch culvert at Arana Gulch (Station 171+03) downstream of Highway 1 crossing